

1        **Amendment to the Claims**

2        **In the Claims:**

3            Please amend Claim 11 and Claim 20 as follows:

4            1. (Original) A method for automatically determining a contour of a left ventricle of a heart,  
5            based upon digital image data from a contrast-enhanced left ventriculogram, said image data  
6            including a sequence of image frames of the left ventricle made over an interval of time during which  
7            the heart has completed more than one cardiac cycle, said method comprising the steps of:

8                (a)        from the sequence of image frames, choosing end diastole (ED) and end  
9                systole (ES) image frames to be segmented;

10              (b)        indicating anatomic landmarks in the ED and ES image frames that were  
11               chosen;

12              (c)        calculating a pre-determined set of feature images from the sequence of image  
13               frames, the ED and ES image frames, and the anatomic landmarks, the step of calculating including  
14               the step of de-flickering the image frames to substantially eliminate variations in intensity introduced  
15               into the image data when the left ventriculogram was produced;

16              (d)        training a pixel classifier for a given set of feature images, using manually  
17               segmented ventriculograms produced for other left ventriculograms as training data;

18              (e)        extracting boundary pixels by using the pixel classifier to classify pixels that  
19               are inside and outside of the left ventricle in the ED and ES image frames; and

20              (f)        fitting a smooth curve to the boundary pixels extracted from the classifier  
21               output for both the ED and ES image frames, to indicate the contour of the left ventricle for ED and  
22               ES portions of the cardiac cycle.

23            2. (Original) The method of Claim 1, wherein the step of calculating the pre-determined set  
24               of feature images includes the step of masking the ventriculogram image frames with a mask that  
25               substantially excludes pixels in the ventriculogram image frames that are outside the left ventricle.

26            ///

27            ///

28            ///

29            ///

30            ///

1           3. (Original) The method of Claim 1, wherein the step of de-flickering comprises the steps  
2 of:

3                   (a) applying a mask to the sequence of image frames;  
4                   (b) determining a gray-level median image; and  
5                   (c) using repeated median regression to produce de-flickered image frames.

6           4. (Original) The method of Claim 1, wherein the pixel classifier includes two stages,  
7 including a first stage classifier and a second stage classifier that operate sequentially, so that an  
8 output of the first stage classifier is input to the second stage classifier.

9           5. (Original) The method of Claim 4, further comprising the step of spatially blurring the  
10 output of the first stage for input to the second stage.

11           6. (Original) The method of Claim 4, wherein each of the first and the second classifier  
12 stages includes separate ED and ES classifiers.

13           7. (Original) The method of Claim 6, wherein the ED and ES classifiers comprise decision  
14 trees.

15           8. (Original) The method of Claim 6, wherein the ED and ES classifiers are boosted decision  
16 trees that use an AdaBoost.M1 algorithm for classifying images.

17           9. (Original) The method of Claim 1, wherein the step of fitting the smooth curve includes  
18 the step of determining the boundary pixels using dilation and erosion.

19           10. (Original) The method of Claim 1, wherein the step of fitting the smooth curve includes  
20 the steps of:

21                   (a) generating a control polygon for a boundary of the left ventricle in the  
22 contrast-enhanced left ventriculogram, with labels corresponding to the anatomic landmarks;

23                   (b) subdividing the control polygon to produce a subdivided polygon having an  
24 increased smoothness;

25                   (c) rigidly aligning the subdivided polygon with the anatomic landmarks of the left  
26 ventricle; and

27                   (d) fitting the subdivided polygon with the ED and ES image frames and the  
28 anatomic landmarks, to produce a reconstructed border of the left ventricle for ED and ES.

29           ///

30           ///

1        11. (Currently Amended) A system for automatically determining a contour of a left  
2 ventricle of a heart, based upon digital image data from a contrast-enhanced left ventriculogram, said  
3 image data including a sequence of image frames of the left ventricle made over an interval of time  
4 during which the heart has completed more than one cardiac cycle, comprising:

- 5                (a) a display;
- 6                (b) a nonvolatile storage for the digital image data and for machine language  
instructions used in processing the digital image data; and
- 7                (c) a processor coupled to the display and to the nonvolatile storage, said  
processor executing the machine language instructions to carry out a plurality of functions, including:
  - 8                        (i) from the sequence of image frames, choosing end diastole (ED) and  
end systole (ES) image frames to be segmented;
  - 9                        (ii) indicating anatomic landmarks in the ED and ES image frames that  
were chosen;
  - 10                        (iii) calculating a pre-determined set of feature images from the sequence of  
image frames, the ED and ES image frames, and the anatomic landmarks, the step of calculating  
including the step of de-flickering the image frames to substantially eliminate variations in intensity  
introduced into the image data when the left ventriculogram was produced;
  - 11                        (iv) training a pixel classifier for a given set of feature images, using  
manually segmented ventriculograms produced for other left ventriculograms as training data;
  - 12                        (v) extracting boundary pixels by using the pixel classifier to classify  
pixels that are inside and outside of the left ventricle in the ED and ES image frames; and
  - 13                        (vi) fitting a smooth curve to the boundary pixels extracted from the  
classifier output for both the ED and ES image frames, to indicate the contour of the left ventricle for  
ED and ES portions of the cardiac cycle.

14        12. (Original) The system of Claim 11, wherein the machine instructions further cause the  
15 processor to mask the ventriculogram image frames with a mask that substantially excludes pixels in  
16 the ventriculogram image frames that are outside of a left ventricle.

17        ///  
18        ///  
19        ///

13. (Original) The system of Claim 11, wherein the machine instructions de-flicker the image frames by:

- (a) applying a mask to the sequence of image frames to substantially exclude pixels that are outside of a left ventricle;
- (b) determining a gray-level median image; and
- (c) using repeated median regression to produce de-flickered image frames.

14. (Original) The system of Claim 11, wherein the pixel classifier includes two stages, including a first stage classifier and a second stage classifier that operate sequentially, so that an output of the first stage classifier is input to the second stage classifier.

15. (Original) The system of Claim 14, wherein the machine instructions further cause the processor to spatially blur the output of the first stage for input to the second stage.

16. (Original) The system of Claim 14, wherein each of the first and the second classifier stages includes separate ED and ES classifiers.

17. (Original) The system of Claim 16, wherein the ED and ES classifiers comprise decision trees.

18. (Original) The system of Claim 16, wherein the ED and ES classifiers are boosted decision trees that use an AdaBoost.M1 algorithm for classifying images.

19. (Original) The system of Claim 11, wherein the machine instructions further cause the processor to determine the boundary pixels using dilation and erosion to fit the smooth curve.

20. (Currently Amended) The system of Claim 11 wherein the machine instructions further cause the processor to fit the smooth curve by:

- (a) generating a control polygon for a boundary of a left ventricle in a ventriculogram, with labels corresponding to the anatomic landmarks;
- (b) subdividing the control polygon to produce a subdivided polygon having an increased smoothness;
- (c) rigidly aligning the subdivided polygon with the anatomic landmarks of the left ventricle; and
- (d) fitting the subdivided polygon with the ED and ES image frames and the anatomic landmarks, to produce a reconstructed border of the left ventricle for ED and ES.